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KupRite: Get Your Dishes Done Right

Colin Joy
Iowa State University, cbjoy@iastate.edu

Dylan Posegate
Iowa State University, posegate@iastate.edu

Joe Mum
Iowa State University, jkathian@iastate.edu

Joseph R. Vanstrom
Iowa State University, vanstrom@iastate.edu

Jacek A. Koziel
Iowa State University, koziel@iastate.edu

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Problem Statement
KupRite is a startup business as of now. The KupRite idea was formed by Heather Blauer about 15 years ago. In the summer of 2016, while camping, she decided to share her idea with Kyle Steele who is now her partner with the aim of turning the KupRite concept into a business opportunity. “This led them to Scott Swenson, a consultant with the SBDC who introduced them to amazing resources”, said Kyle and Heather. One of the resources provided was BeraTek Industries which they utilized for their initial design and the prototype.

Sometimes when light cups, Tupperware, and toddler sippy cups are loaded on the top rack of a dishwasher, they flip and get filled with dirty water, hence leaving them unclean. This is the problem these two entrepreneurs are aiming to resolve with the KupRite product. They wanted us to improve their initial design, recommend better materials, identify potential suppliers and component producers, design for manufacturing (DFM) plan for small-scale production, and plan for scaling up that production.

In an attempt of determining the KupRite market size, there are roughly 93.45 million dishwashers used domestically. Blauer and Steele conducted a personal communication survey that shows 75% of US households are having this flip dish problem (Blauer). See appendixes (#1). They plan on penetrating 1% of the total user market which will result in sales of 690k units. As for competitors, they have Boon Span Dishwasher Net and Band It Dishwasher Loop currently in operation in the market. But once it is all said and done, the KupRite product will be leagues above the competition because it will deliver style, elegance, convenience, and flexibility while also incorporating user-friendly features.

Disciplines
Bioresource and Agricultural Engineering | Industrial Technology

IOWA STATE UNIVERSITY

Department of Agricultural and Biosystems Engineering (ABE)

TSM 416 Technology Capstone Project

KupRite: Get Your Dishes Done Right

Colin Joy[a], Dylan Posegate [b], Joe Mum 3[c], Joseph R. Vanstrom [d*]and Jacek A. Koziel [e*]

[a] Industrial Technology, ABE, ISU, cbjoy@iastate.edu, (847) 660-4894
[b] Industrial Technology, ABE, ISU, posegate@iastate.edu, (515) 291-2197
[c] Industrial Technology, ABE, ISU, jkathian@iastate.edu, (515) 509-5761
[d] Dept. of Agricultural and Biosystems Engineering, ISU, 2321 Elings Hall, Ames, IA 50011, vanstrom@iastate.edu, (515) 294-9955
[e] Dept. of Agricultural and Biosystems Engineering, ISU, 4350 Elings Hall, Ames, IA 50011, koziel@iastate.edu, (515) 294-4206

*course instructors and corresponding authors.

Client: KupRite, Cedar Rapids, Iowa

- Contacts: Heather Blauer, Founder, heather.cousins@hotmail.com, 319-431-1248; Kyle Steele, Founder, ksteele85@gmail.com, 319-981-2378

1 PROBLEM STATEMENT

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2 GOAL STATEMENT

- To improve the design of the product
- Plan for how it is going to be manufactured
  - Small-scale production
  - Large-scale production
- To establish a lowest cost per unit
  - Design improvements
    - Finding the ideal material
    - Reduce material used to lower the cost per unit
    - Improve the structure of the product to help the integrity
  - Production improvements
    - Cost analysis
      - 3D printing vs injection molding
    - Finding the most cost-efficient 3D printer that will produce quality parts
    - Finding an injection molding company that has the capability of producing large parts with a lower mold cost

The main objective was to produce an improved prototype, develop a small-scale production, and a plan to scale up that production.

- Criteria
  - Passes the aesthetic standards from our clients
  - To be more user-friendly than the competition
  - A retractable mesh that fits the top rack of a consumer dishwasher
- Constraint
  - Budget under $25,000
  - Deadline for small-scale production
    - End 2018
  - To have materials withstand dishwasher temperatures while being food grade safe and durable

3 PROJECT PLAN/OUTLINE

Methods/Approach

- Reference Materials
  - Prototype supplied by BeraTek Industries before we started the KupRite project
  - We gained inspiration from the previous capstone group “Building of a Prototype Grain Dryer” with building a prototype of their solution (Wilson et al., 2017)
  - Plastic material information
    - Everything You Need to Know About ABS Plastic (Rogers, 2018)
    - Degradation and Recyclability of Poly (Ethylene Terephthalate) (S. Venkatachalam et al., 2012)
    - PET Facts (International)
    - 3D printing websites that share the basic knowledge, tips, and tricks for 3D printers
  - Cascade Dishwasher detergent information (Procter-Gamble, 2018)
- Original design issues
  - Structural integrity
  - Glue application for assembly

    - Fabric Mesh would absorb dishwasher environment
- 3D Printing plastic filament material
    - See appendixes (#2)
    - PLA used for fit and form to improve the design and create a new prototype
    - ABS testing, RTI will fail in the conditions/environment of a dishwasher
    - PETG needs more testing in the conditions/environment of a dishwasher
        - Deflection tests at high temperatures with a 400g weight, PETG started to soften at 170 °F to 176 °F (Edstrom)
        - Hydrolysis and the effects of pH: "The presence of moisture and acid/alkaline impurities will affect hydrolysis" … "hydrolytic degradation of polyester causes increase of elongation at break due to more chain scissions excepting samples degraded at higher temperature for more than 20 days in which elongation at break will decrease due to more weak points." (S. Venkatachalam et al., 2012)
- Data collection
    - The KupRite product is intended to be used in a dishwasher
        - A typical consumer dishwasher gets as hot as 170 degrees Fahrenheit
        - A typical consumer dishwasher's rack dimensions are 24-inch length by 22-inch width
    - KupRite's first prototype
        - Reverse engineered all the components and developed a 3D model in Autodesk Inventor
    - Find the best 3D printer for our need
        - Compare and contrast the specifications and features of fused deposition modeling (FDM) 3D printers
    - 3D printer cost breakdown table, see appendixes (#3)
    - Mesh material
        - We did not find a mesh that fits all the criteria, see appendixes (#4)
        - We have ruled out serval possibilities
- Skills
    - See appendixes (#5)
- Proposed solutions
    - Injection molding large parts - main body, right & left end caps
        - Work with BeraTek Industries to lock in partnership
        - Recommend high-density polyethylene
        - See appendixes (#6)
    - 3D printing small parts - right & left hooks, pulling handle, spring cylinder, and spring rod
        - Cost analysis based on 80% successful prints
        - See appendixes (#7)
    - Suppliers for the spring, cylinder rod, pull bar, and mesh
- Organization
    - Milestones
        - Prototype, cost analysis, finding the best materials, designing the product, DFM for product, fabrication, and testing, plan for scaling up production
- Deliverables
    - Re-engineered the 3D design and produced a prototype
    - Initial testing of the product
    - Improved the design based on testing
    - Identified potential suppliers and component producers
    - Design for manufacturing
        - For small-scale production
        - Plan for scaling up of production
- Timeline

- See appendixes (#8)

4 BROADER OPPORTUNITY STATEMENT

- Our product is made to provide a solution to a nuisance problem but also provides health benefits
  - If a cup flips in the dishwasher and is not cleaned properly, would allow the possibility of bacteria buildup that could make someone sick
- Compared to competitors, our product is a lot more user-friendly and appealing
  - Most of the general public understands the problem and can see how the KupRite would resolve the problem
- Users of a dishwasher have an opportunity to experience the problems that the KupRite can fix
- Other than just in-home dishwashers, this product could be redesigned for industrial use such as dishwashers at restaurants
  - This would reduce time wasted by employees because getting it right the first time is necessary
- The KupRite in its current form can be used in all standard wire rack dishwashers
  - KupRite could partner with a major dishwasher manufacturer in the future
- Very few competitors with similar ideas
  - Compared to our competitors our product is user-friendly and looks aesthetically pleasing
  - Against our two competitors, our disadvantage is that the KupRite costs more

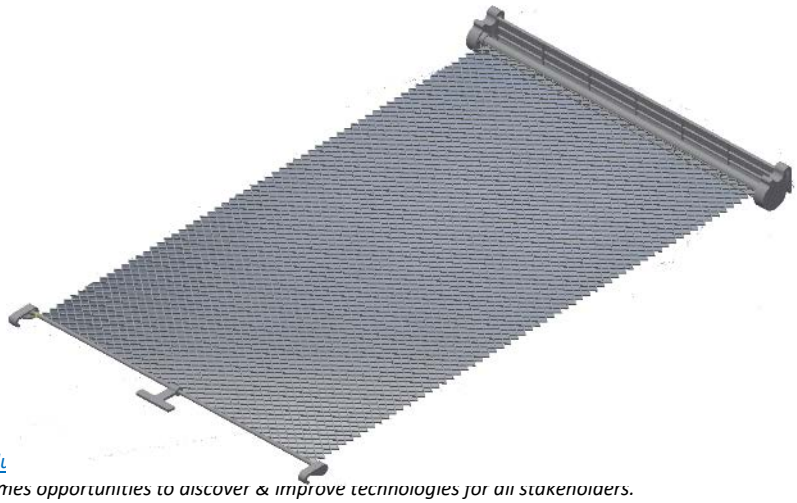
5 PROJECT SCOPE

- Our goals were:
  - Redesign the prototype we acquired from our clients
  - Design a plan for manufacturing
  - Cost Analysis
  - Identify suppliers
  - Identify companies to outsource big parts

6 GRAPHICAL ABSTRACT

Graphical Abstract

These images are our recreation of the prototype made by BeraTek Industries. KupRite: I



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8 APPENDIXES

#1 Personal Communication Survey (Blauer)

Total # of Dishwashers Domestically	74% Of Owners Identify Having This Issue	0.1% of Total "Sellable" Audience	Price per Unit	Total Sales	Amazon/Beratek Fees	Net Proceeds 1% of market penetration
93,450,000	69,000,000	69,000	$19.99	$1,379,310.00	$965,620.50	$413,689.50
Total # of Dishwashers Domestically	**74% Of Owners Identify Having This Issue**	**1% of Total "Sellable" Audience**	**Price per Unit**	**Total Sales**	**Amazon/Beratek Fees**	**Net Proceeds 1% of market penetration**
93,450,000	69,000,000	690,000	$19.99	$13,793,100.00	$9,656,205.00	$4,136,895.00
Total # of Dishwashers Domestically	**74% Of Owners Identify Having This Issue**	**10% of Total "Sellable" Audience**	**Price per Unit**	**Total Sales**	**Amazon/Beratek Fees**	**Net Proceeds 10% of market penetration**
93,450,000	69,000,000	6,900,000	$19.99	$137,931,000.00	$96,562,050.00	$41,368,950.00

#2 Plastic filament material

	PLA	ABS	PETG
Glass Transition Temprature	149 degrees fahrenheit	221 degrees fahrenheit	180 degrees fahrenheit
Relative Thermal Index	-	140 degrees fahrenheit	284 degrees fahrenheit
Printability	Easy	Hard	Easy
Quality	Visible layers	Can be vapor smothed	Visible layers
FDA Approved	N/A	N/A	Yes
Did it work for our application	No	No	Maybe, needs more testing

#3 3D printer cost breakdown table

3D Printer	Price	Length (mm)	Width (mm)	Height (mm)	Volume (mm^3)	Print Speed (mm/s)	Layer resolution (mm)	Filament Diameter (mm)	Nozzle Diameter (mm)	Print Head	Self-Leveling
Lulzbot Taz 6	$2,500	284.5	284.5	248.9	20,144,814	30-200	0.05	2.85	0.5	1	✓
CR-10	$380	300.0	300.0	400.0	35,999,784	100 - 200	0.05	1.75	0.4	1	
CR-10S 4	$800	400.0	400.0	400.0	63,999,616	100 - 200	0.05	1.75	0.4	1	
CR-10S 5	$1,100	500.0	500.0	500.0	124,999,250	100 - 200	0.05	1.75	0.4	1	
CR-10S	$560	300.0	300.0	400.0	35,999,784	80-200	0.05	1.75	0.4	1	
Ultimaker 2+	$2,500	223.0	223.0	205.0	10,194,448	50	0.05	2.85	0.4	1	✓
Ultimaker 3	$3,500	214.9	214.9	199.9	9,230,317	50	0.05	2.85	0.4	2	✓

#4 Criteria table for the KupRite Mesh

	Criteria for the KupRite Mesh					
Tested Mesh	Food Grade Safe	Temprature Resistant > 180° F	Durability	Rolling Capibility	Antimicrobial Material	Astedically Pleasing
Polypropylene XN1673	✓	✓	X	X	✓	✓
Polypropylene XN0260	✓	✓	X	X	✓	✓
Polypropylene XN2950	✓	✓	X	X	✓	✓
Polypropylene XN2335	✓	✓	X	X	✓	✓
Nylon NN4825	X	✓	✓	X	X	✓
Rubber Mesh From Heather and Kyle	X	X	✓	X	X	✓

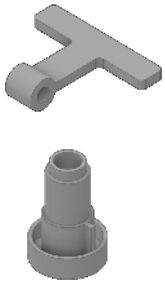
#5 Skills

TSM 115	Problem solving cycle
TSM 116/216	3D design
TSM 210	Critical thinking & prototyping solutions
TSM 214	Project initiation and planning
TSM 240	3D printing and material properties
TSM 340	Cost analysis
TSM 444	Project planning

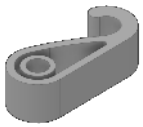
#6 Injection molding large Parts

	Bruin	Lomont	BeraTek
Tooling Material	Aluminum	Aluminum	Aluminum
Main body with End caps	N/A	$ 44,500	$ 18,000
Main body	$20,952	N/A	$ 14,000

#7 3D printing small parts



Part	Material (grams)
Pulling Handle	2.47
Right Hook	1.675
Left Hook	1.675
Spring Cylinder	0.75
Spring Rod	2.1
Total (Set)	8.67



	Cost	Material (grams)	Set / 1 Kg	Cost / Set
PETG	$28.00	1000	115	$ 0.24
PETG Pro	$38.00	1000	115	$ 0.33

	80% Success	Cost / Set
PETG	92	$ 0.30
PETG Pro	92	$ 0.41

#8 Timeline

- Define the project - Week of 10/20/2017
- Cost analysis for injection molding vs 3D printing - Week of 11/3/2017
  - Finding suppliers for injection molding and getting quotes - Week of 10/27/2017
  - Finding the best 3D printers that fit criteria - Week of 11/3/2017
- Finding the best material for 3D printing/mesh - Week of 12/1/2017
  - Material properties - Week of 11/10/2017
  - Cost of Material - Week of 11/17/2017
  - Supplier material for spring mechanism - Week of 12/1/2017
- Designing the product - Week of 12/15/2017
  - Taking measurements - Week of 12/8/2017
  - Drafting in Autodesk Inventor - Week of 12/8/2017
  - Design improvements - Week of 12/15/2017
    - Design for injection molding – Week of 1/12/2018
    - Quote for injection molding of the full body – Week of 1/19/2018
    - Supplier for Spring loaded mechanism – Week of 1/26/2018
    - Supplier for mesh – Week of 2/2/2018
    - Spring-loaded mechanism housing – Week of 2/9/2018
    - Final design – Week of 2/9/2018
    - Testing – Weeks of 2/16/2018 - 2/23/2018
      - ABS material in a dishwasher – Week of 2/9/2018
      - Nylon X material in a dishwasher – Week of 2/9/2018
      - PETG material in a dishwasher – Week of 2/16/2018
      - Polycarbonate material in a dishwasher – Week of 2/16/2018
      - Mesh material in a dishwasher – Week of 2/23/2018
      - Durability with thicknesses – Week of 2/23/2018
    - Plan for scaling up of production – Week of 3/9/2018